Oxygen-XANES Measurements on Interplanetary Dust Particles

G.J. Flynn (SUNY, Plattsburgh), M. Feser (SUNY, Stony Brook), L.P. Keller (NASA Johnson Space Center), C. Jacobsen and S. Wirick (SUNY, Stony Brook)

Abstract No. Flyn1070
Beamline(s): **X1A**

Introduction: Anders (1989) suggested the accretion of interplanetary dust particles (IDPs) onto the early Earth should have provided a surface layer rich in organic matter that may have been important to the emergence of life on Earth. Implicit in Anders (1989) modeling is the assumption that IDPs contain a significant abundance of organic matter. Clemett *et al*. (1993) detected polycyclic aromatic hydrocarbons (PAHs) in some IDPs using laser desorption laser ionization mass spectroscopy. However, the abundance of PAHs was not determined, and the carbon in some IDPs is reported to be mostly elemental amorphous carbon (Keller, 1994; Bajt *et al*., 1996). To determine the abundance and types of carbon in IDPs, we used the Scanning Transmission X-Ray Microscope at X1A to map the carbon distribution in IDPs and then to determine the carbon functional groups in carbon-rich regions using C-XANES spectroscopy. The C-XANES spectra of the carbonaceous matter in most IDPs are indistinguishable from the C-XANES spectrum of acid insoluble residue, prepared by dissolving the silicates and sulfides by repeated HF and HCl treatments, from the carbonaceous meteorites Murray and Murchison. This residue from Murray and Murchison is dominated by organic matter. Furthermore, the C-XANES spectra of the carbonaceous matter in most IDPs have pre-edge absorption peaks at ~288.6 eV, an energy usually associated with carbon to oxygen bonding. However, Bajt *et al*. (1996) noted the C-XANES spectrum of the carbonaceous matter in IDPs is similar to that of C_{60} (which has a strong absorption near 288.5 eV), or possibly a degraded form of C_{60}, leaving the possibility that IDPs might be dominated by an unusual form of elemental carbon.

Methods and Materials: To determine if the 288.6 eV absorption in the carbon-rich regions of the IDPs is due to carbon to oxygen bonding and to assess roughly the C to O ratio in this carbon-rich material in the IDPs we performed oxygen K-edge XANES measurements on two IDPs – L2011*B2 and Dragonfly. The O-XANES spectra were collected with the scanning transmission X-ray microscope "STXM 4" at beamline X-1A at the NSLS. The instrument operates in a closed Helium atmosphere to eliminate X-ray absorption in air and offers the necessary sub-100 nanometer spatial resolution.

Results: **Figure 1** is an image of part of a section of L2011*B2, with one of the carbon-rich regions marked by arrows. The O-XANES spectra of the carbon-rich regions of both IDPs showed strong absorption at the O K-edge and a strong pre-edge absorption at ~531 eV, an energy consistent with literature data for the C=O double bond (see **Figure 2**). The silicate regions of the IDPs also showed strong O K-edge absorption, consistent with the O content of these silicates, but no pre-edge absorption (see **Figure 2**).

Conclusions: The height of the O K-edge demonstrates that the carbonaceous matter in the two IDPs examined thus far contains a significant amount of oxygen, and the presence and strength of the pre-edge absorption peak demonstrates that much of that oxygen is double-bonded to carbon. These measurements at the O K-edge eliminate the possibility that the ~288.6 eV pre-edge absorption we measured at the C K-edge might have resulted exclusively from elemental carbon – either C_{60} or some degraded form of C_{60}.

Acknowledgments: This work was supported by NASA Exobiology Grant NAG5-469101, JSC Astrobiology Institute Grant NAG9-1109 and NASA RTOP 344-31-40-06.

References: E. Anders, Nature, 342, 244-257, 1989. S. Bajt *et al*., Lunar & Planetary Science XXVII, 57-58, 1996. S. J. Clemett *et al*., Science, 262, 721-724, 1993. J. R. Cronin et al., in Meteorites and the Early Solar System, U. of Arizona Press, 819-857, 1988. L. P. Keller *et al*., in AIP Conf Proc. 319, AIP Press, 159-163, 1994.

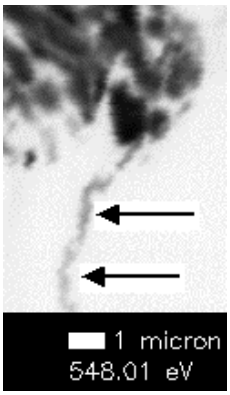

Figure 1. STXM 4 image of a microtomed section of the interplanetary dust particle L2011*B2. The arrows indicate the carbon rich regions on which O-XANES spectra were collected.

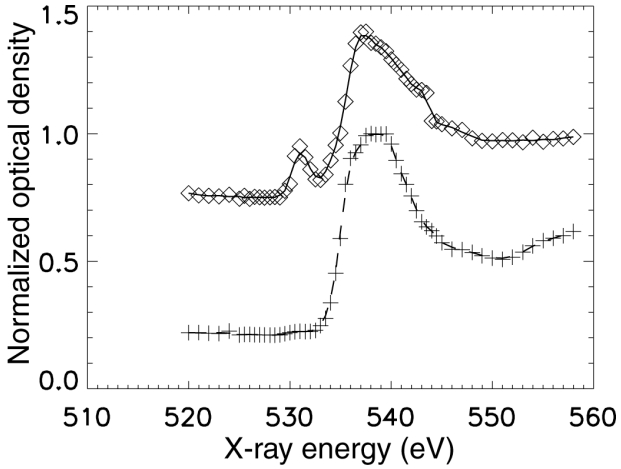

Figure 2. O-XANES spectrum from L2011*B2. The continuous line is a spectrum from a carbon rich region. The dashed line is a spectrum collected from the bulk of the particle which lacks the C=O double bond feature.